

## Description

# [GOLF BALL HAVING A POLYURETHANE COVER(Corporate Docket Number PU2163)]

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part application of U.S. Patent Application Number 09/682,866, filed on October 25, 2001, which is a continuation-in-part application of U.S. Patent Application Number 09/562,782, filed on May 2, 2000, now U.S. Patent Number 6,511,388, which is a divisional application of U.S. Patent Application Number 09/295,635, filed on April 20, 1999, now U.S. Patent Number 6,117,024.

### FEDERAL RESEARCH STATEMENT

[0002] [Not Applicable]

### BACKGROUND OF INVENTION

[0003] Field of the Invention

[0004] The present invention relates to a cover for a golf ball. More specifically, the present invention relates to a golf ball cover layer composed of a thermosetting polyurethane.

[0005] Description of the Related Art

[0006] Conventionally golf balls are made by molding a cover around a core. The core may be wound or solid. A wound core typically comprises elastic thread wound about a solid or liquid center. Unlike wound cores, solid cores do not include a wound elastic thread layer. Solid cores typically may comprise a single solid piece center or a solid center covered by one or more mantle or boundary layers of material.

[0007] The cover may be injection molded, compression molded, or cast over the core. Injection molding typically requires a mold having at least one pair of mold cavities, e.g., a first mold cavity and a second mold cavity, which mate to form a spherical recess. In addition, a mold may include more than one mold cavity pair.

[0008] In one exemplary injection molding process each mold cavity may also include retractable positioning pins to hold the core in the spherical center of the mold cavity pair. Once the core is positioned in the first mold cavity,

the respective second mold cavity is mated to the first to close the mold. A cover material is then injected into the closed mold. The positioning pins are retracted while the cover material is flowable to allow the material to fill in any holes caused by the pins. When the material is at least partially cured, the covered core is removed from the mold.

[0009] As with injection molding, compression molds typically include multiple pairs of mold cavities, each pair comprising first and second mold cavities that mate to form a spherical recess. In one exemplary compression molding process, a cover material is pre-formed into half-shells, which are placed into a respective pair of compression mold cavities. The core is placed between the cover material half-shells and the mold is closed. The core and cover combination is then exposed to heat and pressure, which cause the cover half-shells to combine and form a full cover.

[0010] As with the above-referenced processes, a casting process also utilizes pairs of mold cavities. In a casting process, a cover material is introduced into a first mold cavity of each pair. Then, a core is held in position (e.g. by an overhanging vacuum or suction apparatus) to contact the

cover material in what will be the spherical center of the mold cavity pair. Once the cover material is at least partially cured (e.g., a point where the core will not substantially move), the core is released, the cover material is introduced into a second mold cavity of each pair, and the mold is closed. The closed mold is then subjected to heat and pressure to cure the cover material thereby forming a cover on the core. With injection molding, compression molding, and casting, the molding cavities typically include a negative dimple pattern to impart a dimple pattern on the cover during the molding process.

[0011] Materials previously used as golf ball covers include balata (natural or synthetic), gutta-percha, ionomeric resins (e.g., DuPont's SURLYN®), and polyurethanes. Balata is the benchmark cover material with respect to sound (i.e. the sound made when the ball is hit by a golf club) and feel (i.e. the sensation imparted to the golfer when hitting the ball). Natural balata is derived from the Bully Gum tree, while synthetic balata is derived from a petroleum compound. Balata is expensive compared to other cover materials, and golf balls covered with balata tend to have poor durability (i.e. poor cut and shear resistance). Gutta percha is derived from the Malaysian sapodilla tree. A golf

ball covered with gutta percha is considered to have a harsh sound and feel as compared to balata covered golf balls.

[0012] Ionomeric resins, as compared to balata, are typically less expensive and tend to have good durability. However, golf balls having ionomeric resin covers typically have inferior sound and feel, especially as compared to balata covers.

[0013] A golf ball with a polyurethane cover generally has greater durability than a golf ball with a balata cover. The polyurethane covered golf ball generally has a better sound and feel than a golf ball with an ionomeric resin cover. Polyurethanes may be thermoset or thermoplastic. Polyurethanes are formed by reacting a prepolymer with a polyfunctional curing agent, such as a polyamine or a polyol. The polyurethane prepolymer is the reaction product of, for example, a diisocyanate and a polyol such as a polyether or a polyester. Several patents describe the use of polyurethanes in golf balls. However, golf balls with polyurethane covers usually do not have the distance of other golf balls such as those with covers composed of SURLYN® materials.

[0014] Gallagher, U.S. Patent Number 3,034,791 discloses a polyurethane golf ball cover prepared from the reaction

product of poly(tetramethylene ether) glycol and toluene-2,4-diisocyanates (TDI), either pure TDI or an isomeric mixture.

[0015] Isaac, U.S. Patent Number 3,989,568 (the '568 patent) discloses a polyurethane golf ball cover prepared from prepolymers and curing agents that have different rates of reaction so a partial cure can be made. The '568 patent explains that "the minimum number of reactants is three". Specifically, in '568 patent, two or more polyurethane prepolymers are reacted with at least one curing agent, or at least one polyurethane prepolymer is reacted with two or more curing agents as long as the curing agents have different rates of reaction. The '568 patent also explains that "[o]ne of the great advantages of polyurethane covers made in accordance with the instant invention is that they may be made very thin ....", and "[t]here is no limitation on how thick the cover of the present invention may be but it is generally preferred ...that the cover is no more than about 0.6 inches in thickness." The examples in the '568 patent only disclose golf balls having covers that are about 0.025 inches thick.

[0016] Similar to Isaac, PCT International Publication Number WO 99/43394 to Dunlop Maxfli Sports Corporation, discloses

using two curing agents to control the reaction time for polyurethane formation. The two curing agents are a dimethylthio 2,4-toluenediamine and diethyl 2,4-toluenediamine, which are blended to control the reaction rate of a toluene diisocyanate based polyurethane prepolymer or a 4,4'-diphenylmethane diisocyanate based polyurethane prepolymer.

[0017] Dusbiber, U.S. Patent Number 4,123,061 (the '061 patent) discloses a polyurethane golf ball cover prepared from the reaction product of a polyether, a diisocyanate and a curing agent. The '061 patent discloses that the polyether may be polyalkylene ether glycol or polytetramethylene ether glycol. The '061 patent also discloses that the diisocyanate may be TDI, 4,4'-diphenylmethane diisocyanate ("MDI"), and 3,3'-dimethyl-4,4'-biphenylene diisocyanate ("TODI"). Additionally, the '061 patent discloses that the curing agent may be either a polyol (either tri- or tetra-functional and not di-functional) such as triisopropanol amine ("TIPA") or trimethoylol propane ("TMP"), or an amine-type having at least two reactive amine groups such as: 3,3' dichlorobenzidine; 3,3' dichloro 4,4' diamino diphenyl methane ("MOCA"); N,N,N',N' tetrakis (2-hydroxy propyl) ethylene diamine; or Uniroyal's Curalon L which is

an aromatic diamine mixture.

[0018] Hewitt, et al., U.S. Patent Number 4,248,432 (the '432 patent) discloses a thermoplastic polyesterurethane golf ball cover formed from a reaction product of a polyester glycol (molecular weight of 800–1500) (aliphatic diol and an aliphatic dicarboxylic acid) with a para-phenylene diisocyanate ("PPDI") or cyclohexane diisocyanate in the substantial absence of curing or crosslinking agents. The '432 patent teaches against the use of chain extenders in making polyurethanes. The 432 patent states, "when small amounts of butanediol–1,4 are mixed with a polyester ... the addition results in polyurethanes that do not have the desired balance of properties to provide good golf ball covers. Similarly, the use of curing or crosslinking agents is not desired ...".

[0019] Holloway, U.S. Patent Number 4,349,657 (the '657 patent) discloses a method for preparing polyester urethanes with PPDI by reacting a polyester (e.g. prepared from aliphatic glycols having 2–8 carbons reacted with aliphatic dicarboxylic acids having 4–10 carbons) with a molar excess of PPDI to obtain an isocyanate-terminated polyester urethane (in liquid form and stable at reaction temperatures), and then reacting the polyester urethane with additional



polyester. The '657 patent claims that the benefit of this new process is the fact that a continuous commercial process is possible without stability problems. The '657 patent further describes a suitable use for the resultant material to be golf ball covers.

[0020] Wu, U.S. Patent Number 5,334,673 (the '673 patent) discloses a polyurethane prepolymer cured with a slow-reacting curing agent selected from slow-reacting polyamine curing agents and difunctional glycols (i.e., 3,5-dimethylthio-2,4-toluenediamine, 3,5-dimethylthio-2,6-toluenediamine, N,N'-dialkyldiamino diphenyl methane, trimethyleneglycol-di-p-aminobenzoate, polytetramethyleneoxide-di-p-aminobenzoate, 1,4-butanediol, 2,3-butanediol, 2,3-dimethyl-2,3-butanediol, ethylene glycol, and mixtures of the same). The polyurethane prepolymer in the '673 patent is disclosed as made from a polyol (e.g., polyether, polyester, or polylactone) and a diisocyanate such as MDI or TODI. The polyether polyols disclosed in the '673 patent are polytetramethylene ether glycol, poly(oxypropylene) glycol, and polybutadiene glycol. The polyester polyols disclosed in the '673 patent are polyethylene adipate glycol, polyethylene propylene adi-

pate glycol, and polybutylene adipate glycol. The polylactone polyols disclosed in the '673 patent are diethylene glycol initiated caprolactone, 1,4-butanediol initiated caprolactone, trimethylol propane initiated caprolactone, and neopentyl glycol initiated caprolactone.

[0021] Cavallaro, et al., U.S. Patent Number 5,688,191 discloses a golf ball having core, mantle layer and cover, wherein the mantle layer is either a vulcanized thermoplastic elastomer, functionalized styrene-butadiene elastomer, thermoplastic polyurethane, metallocene polymer or blends of the same and thermoset materials.

[0022] Wu, et al., U.S. Patent Number 5,692,974 discloses golf balls having covers and cores that incorporate urethane ionomers (i.e. using an alkylating agent to introduce ionic interactions in the polyurethane and thereby produce cationic type ionomers).

[0023] Sullivan, et al., U.S. Patent Number 5,803,831 (the '831 patent) discloses a golf ball having a multi-layer cover wherein the inner cover layer has a hardness of at least 65 Shore D and the outer cover layer has a hardness of 55 Shore D or less, and more preferably 48 Shore D or less. The '831 patent explains that this dual layer construction provides a golf ball having soft feel and high spin on short

shots, and good distance and average spin on long shots. The '831 patent provides that the inner cover layer can be made from high or low acid ionomers such as SURLYN®, ESCOR® or IOTEK®, or blends of the same, nonionomeric thermoplastic material such as metallocene catalyzed polyolefins or polyamides, polyamide/ionomer blends, polyphenylene ether / ionomer blends, etc., (having a Shore D hardness of at least 60 and a flex modulus of more than 30000 psi), thermoplastic or thermosetting polyurethanes, polyester elastomers (e.g. HYTREL®), or polyether block amides (e.g. PEBAX®), or blends of these materials. The '831 patent also provides that the outer cover layer can be made from soft low modulus (i.e. 1000–10000 psi) material such as low-acid ionomers, ionomeric blends, non-ionomeric thermoplastic or thermosetting materials such as polyolefins, polyurethane (e.g. thermoplastic polyurethanes like TEXIN®, PELETHANE®, and thermoset polyurethanes like those disclosed in Wu, U.S. Patent Number 5,334,673), polyester elastomer (e.g. HYTREL®), or polyether block amide (e.g. PEBAX®), or a blend of these materials.

[0024] Hebert, et al., U.S. Patent Number 5,885,172 (the '172 patent) discloses a multilayer golf ball giving a "progres-

sive performance" (i.e. different performance characteristics when struck with different clubs at different head speeds and loft angles) and having an outer cover layer formed of a thermoset material with a thickness of less than 0.05 inches and an inner cover layer formed of a high flexural modulus material. The '172 patent provides that the outer cover is made from polyurethane ionomers as described in Wu, et al., U.S. Patent Number 5,692,974, or thermoset polyurethanes such as TDI or methylenebis-(4-cyclohexyl isocyanate) (HMDI), or a polyol cured with a polyamine (e.g. methylenedianiline (MDA)), or with a tri-functional glycol (e.g., N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine). The '172 also provides that the inner cover has a Shore D hardness of 65–80, a flexural modulus of at least about 65,000 psi, and a thickness of about 0.020–0.045 inches. Exemplary materials for the inner cover are ionomers, polyurethanes, polyetheresters (e.g. HYTREL®), polyetheramides (e.g., PEBAX®), polyesters, dynamically vulcanized elastomers, functionalized styrene–butadiene elastomer, metallocene polymer, blends of these materials, nylon or acrylonitrile–butadiene–styrene copolymer.

[0025] Wu, U.S. Patent Number 5,484,870 (the '870 patent) dis-

closes golf balls having covers composed of a polyurea composition. The polyurea composition disclosed in the '870 patent is a reaction product of an organic isocyanate having at least two functional groups and an organic amine having at least two functional groups. One of the organic isocyanates disclosed by the '870 patent is PPDI.

[0026] Although the prior art has disclosed golf ball covers composed of many different polyurethane materials, none of these golf balls have proven completely satisfactory. One particular dissatisfaction has been the yellowing of thermosetting polyurethane covers upon exposure to sunlight (ultraviolet radiation). Thus, there remains a need for thermosetting polyurethane covers that have reduced yellowing while maintaining the other desired properties of a thermosetting polyurethane cover.

#### **SUMMARY OF INVENTION**

[0027] The present invention provides a golf ball that has a cover composed of a thermosetting polyurethane that has increased resistance to yellowing. The golf ball of the present invention is able to accomplish this by providing a cover composed of a thermosetting polyurethane material formed from a polyurethane prepolymer and a curative composed of 20 to 40 parts

4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline and 80 to 60 parts diethyl 2,4-toluenediamine.

[0028] One aspect of the present invention is a golf ball including a core and a cover. The cover is composed of a thermosetting polyurethane material formed from reactants including a polyurethane prepolymer and 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline. The cover has an aerodynamic surface geometry thereon.

[0029] Another aspect of the present invention is a golf ball including a core, a boundary layer and a cover. The core is a polybutadiene mixture and has a diameter ranging from 1.35 inches to 1.64 inches. The core also has a PGA compression ranging from 50 to 90. The boundary layer is formed over the core and is composed of a blend of ionomer materials. The boundary layer has a thickness ranging from 0.020 inch to 0.075 inch and a Shore D hardness ranging from 50 to 75 as measured according to ASTM-D2240. The cover is formed over the boundary layer. The cover is composed of a thermosetting polyurethane material formed from reactants including a polyurethane prepolymer and a curative composed of 20 to 40 parts 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline and 80

to 60 parts diethyl 2,4-toluenediamine. The cover has a Shore D hardness ranging from 30 to 60 as measured according to ASTM-D2240. The cover also has a thickness ranging from 0.015 inch to 0.040 inch and an aerodynamic surface geometry thereon.

[0030] Having briefly described the present invention, the above and further objects, features and advantages thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

#### **BRIEF DESCRIPTION OF DRAWINGS**

[0031] FIG. 1 illustrates a perspective view of a golf ball of the present invention including a cut-away portion showing a core, a boundary layer, and a cover.

[0032] FIG. 2 illustrates a perspective view of a golf ball of the present invention including a cut-away portion core and a cover.

#### **DETAILED DESCRIPTION**

[0033] As illustrated in FIG. 1, the golf ball of the present invention is generally indicated as 10. The golf ball 10 includes a core 12, a boundary layer 14 and a cover 16. Alternatively, as shown in FIG. 2, the golf ball 10 may only in-

clude a core 12 and a cover 16. The cover 16 is preferably composed of a thermosetting polyurethane material formed from a toluene diisocyanate prepolymer and 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline. In a preferred embodiment, the cover 16 is formed over a boundary layer 14 and core 12, as shown in FIG. 1. Alternatively, the cover 16 is formed over the core 12, as shown in FIG. 2. Those skilled in the art will recognize that the core may be solid, hollow, multi-piece or liquid-filled, and the boundary layer may be partitioned into additional layers, without departing from the scope and spirit of the present invention.

[0034] As mentioned above, the thermosetting polyurethane material is formed from a polyurethane prepolymer and a curative composed of a 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline. The polyurethane prepolymer is preferably a polypropylene glycol terminated toluene diisocyanate prepolymer, a polytetramethylene ether glycol terminated toluene diisocyanate prepolymer, or a polytetramethylene ether glycol terminated hexamethylene diisocyanate prepolymer. In a further embodiment, the thermosetting polyurethane material is formed from a polypropylene glycol terminated



toluene diisocyanate prepolymer and a curative composed of 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline and diethyl 2,4-toluenediamine. A preferred polypropylene glycol terminated toluene diisocyanate prepolymer is available from Uniroyal Chemical Company of Middlebury, Connecticut, under the tradename ADIPRENE® LFG960. A preferred polytetramethylene ether glycol terminated toluene diisocyanate prepolymer is available from Uniroyal Chemical Company of Middlebury, Connecticut, under the tradename ADIPRENE® LF930. A preferred polyester terminated toluene diisocyanate prepolymer is available from Uniroyal Chemical Company of Middlebury, Connecticut, under the tradename ADIPRENE® LF1900A. Preferred polytetramethylene ether glycol terminated hexamethylene diisocyanate prepolymers are available from Uniroyal Chemical under the tradenames ADIPRENE® LFH750, ADIPRENE® LFH749 and ADIPRENE® LFH720, which are both aliphatic polyurethane prepolymers.

[0035] Diethyl 2,4-toluenediamine is available from Albemarle Corporation of Baton Rouge, Louisiana under the trade-name ETHACURE® 100.

4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline is available from Air Products and Chemicals Inc., of Allentown,

Pennsylvania, under the tradename LONZACURE™.

[0036] The curative mixture for the cover 16 may have numerous variations. The curative mixture includes 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline in order to control the reaction time and to affect the diminished yellowing of the cover after exposure to sunlight. In a preferred embodiment, the curative mixture is composed of 20 to 40 parts 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline and 80 to 60 parts diethyl 2,4-toluenediamine. A most preferred curative mixture is composed of 30 parts 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline and 70 parts diethyl 2,4-toluenediamine.

[0037] The ratio of the polyurethane prepolymer to curative is determined by the nitrogen-carbon-oxygen group ("NCO") content of the polyurethane prepolymer. For example, the NCO content of the polypropylene glycol terminated toluene diisocyanate prepolymer is preferably in the range of 3.0% to 6.0%, more preferably in the range of 4.0% to 5.75%, and most preferably 5.70%. The NCO content of the polytetramethylene ether glycol terminated toluene diisocyanate prepolymer is preferably in the range of 3.75% to 7.0%, more preferably in the range of 4.0% to

5.75%, and most preferably 5.70%. The NCO content of the polytetramethylene ether glycol terminated hexamethylene diisocyanate prepolymer is preferably in the range of 8.0% to 12.0%, more preferably in the range of 10.0% to 11.5%, and most preferably 11%. The weight ratio of the polyurethane prepolymer to the curative is preferably in the range of about 10:1 to about 30:1.

[0038] Prior to curing, the polyurethane prepolymer and curative are preferably stored separately. The polyurethane material is formed by first heating and mixing the polyurethane prepolymer with the curative in a mold, and then curing the mixture by applying heat and pressure for a predetermined time period. Additionally, a catalyst (e.g. dibutyl tin dilaurate, a tertiary amine, etc.) may be added to the mixture to expedite the casting process. Specific suitable catalysts include TEDA dissolved in di propylene glycol (such as TEDA L33 available from Witco Corp. Greenwich, CT, and DABCO 33 LV available from Air Products and Chemicals Inc.,) which may be added in amounts of 2–5%, and more preferably TEDA dissolved in 1,4–butane diol which may be added in amounts of 2–5%. Another suitable catalyst includes a blend of 0.5% 33LV or TEDA L33 (above) with 0.1% dibutyl tin dilaurate (available from Witco Corp.

or Air Products and Chemicals, Inc.) which is added to a curative such as VIBRACURE® A250. Furthermore, additives such as colorants may also be added to the mixture.

[0039] The polyurethane prepolymer is preferably degassed and warmed in a first holding container prior to processing of the cover 16. The processing temperature for the polyurethane prepolymer is preferably in the range of about 100–220°F, and most preferably in the range of about 120–200°F. The polyurethane prepolymer is preferably flowable from the first holding container to a mixing chamber in a range of about 200–1100 grams of material per minute, or as needed for processing. In addition, the polyurethane prepolymer material may be agitated in the first holding container, in the range of 0–250 rpm, to maintain a more even distribution of material and to eliminate crystallization.

[0040] The curative is preferably degassed and warmed in a second holding container prior to processing of the cover 16. The processing temperature for the curative is preferably in the range of about 50–230°F, and most preferably in the range of about 80–200°F. The curative is preferably flowable from the second holding container to the mixing chamber in the range of about 15–75 grams of material

per minute, or as needed. If a catalyst is used for processing the cover 16, then the catalyst is added to the curing agent in the second holding container to form a curative mixture. Suitable catalyst are described above. The curative and catalyst are agitated, in the range of about 0 to 250 rpm, to maintain an even distribution of catalyst in the curative mixture in the second holding container. It is preferred that the catalyst is added in an amount in the range of about 0.25–5% by weight of the combined polyurethane prepolymer and curative. Additives may be added to the curative mixture as desired. It was discovered that hydrolytic instability of the polyurethane polymer may be avoided by the addition of a stabilizer such as STABOXYL® (available from Rheinchemie, Trenton, New Jersey), in amounts of about 0.25–5% of the polyurethane.

[0041] The polyurethane prepolymer and curative mixture are preferably added to the common mixing chamber at a temperature in the range of about 160–220°F. A colorant material, such as, for example, titanium dioxide, barium sulfate, and/or zinc oxide in a glycol or castor oil carrier, and/or other additive material(s) as are well known in the art, may be added to the common mixing chamber. The amount of colorant material added is preferably in the

range of about 0–10% by weight of the combined polyurethane prepolymer and curative materials, and more preferably in the range of about 2–8%. Other additives, such as, for example, polymer fillers, metallic fillers, and/or organic and inorganic fillers (e.g. polymers, balata, ionomers, etc.) may be added as well to increase the specific gravity of the polyurethane cover 16 of the present invention. It was discovered that the addition of barytes (barium sulfate) or a blend of barytes and titanium dioxide (preferably added in a carrier glycol and/or castor oil) to the mixture, in the amounts of about 0.01–30%, may add sufficient weight to the polyurethane cover 16. The added weight to the cover 16 allows for a lower specific gravity for the core 12 thereby allowing for an increased resiliency of the core 12. The entire mixture is preferably agitated in the mixing chamber in the range of about 1 to 250 rpm prior to molding. A more detailed explanation of the process is set forth in U.S. Patent Number 6,200,512, entitled Golf Balls And Methods Of Manufacturing The Same, filed on April 20, 1999, assigned to Callaway Golf Company, and which is hereby incorporated by reference in its entirety.

[0042] The core 12 of the golf ball 10 is the "engine" for the golf

ball 10 such that the inherent properties of the core 12 will strongly determine the initial velocity and distance of the golf ball 10. A higher initial velocity will usually result in a greater overall distance for a golf ball. In this regard, the Rules of Golf, approved by the United States Golf Association ("USGA") and The Royal and Ancient Golf Club of Saint Andrews, limits the initial velocity of a golf ball to 250 feet (76.2m) per second (a two percent maximum tolerance allows for an initial velocity of 255 per second) and the overall distance to 280 yards (256m) plus a six percent tolerance for a total distance of 296.8 yards (the six percent tolerance may be lowered to four percent). A complete description of the Rules of Golf are available on the USGA web page at [www.usga.org](http://www.usga.org). Thus, the initial velocity and overall distance of a golf ball must not exceed these limits in order to conform to the Rules of Golf. Therefore, the core 12 for a USGA approved golf ball is constructed to enable the golf ball 10 to meet, yet not exceed, these limits.

[0043] The coefficient of restitution ("COR") is a measure of the resilience of a golf ball. The COR is a measure of the ratio of the relative velocity of the golf ball after direct impact with a hard surface to the relative velocity before impact

with the hard surface. The COR may vary from 0 to 1, with 1 equivalent to a completely elastic collision and 0 equivalent to a completely inelastic collision. A golf ball having a COR value closer to 1 will generally correspond to a golf ball having a higher initial velocity and a greater overall distance. If the golf ball has a high COR (more elastic), then the initial velocity of the golf ball will be greater than if the golf ball had a low COR. In general, a higher compression core will result in a higher COR value.

[0044] The core 12 of the golf ball 10 is generally composed of a blend of a base rubber, a cross-linking agent, a free radical initiator, and one or more fillers or processing aids. A preferred base rubber is a polybutadiene having a cis-1,4 content above 90%, and more preferably 98% or above.

[0045] The use of cross-linking agents in a golf ball core is well known, and metal acrylate salts are examples of such cross-linking agents. For example, metal salt diacrylates, dimethacrylates, or mono(meth)acrylates are preferred for use in the golf ball cores of the present invention, and zinc diacrylate is a particularly preferred cross-linking agent. A commercially available suitable zinc diacrylate is SR-416 available from Sartomer Co., Inc., Exton, Pennsylvania. Other metal salt di- or mono- (meth)acrylates suit-



able for use in the present invention include those in which the metal is calcium or magnesium. In the manufacturing process it may be beneficial to pre-mix some cross-linking agent(s), such as, e.g., zinc diacrylate, with the polybutadiene in a master batch prior to blending with other core components.

[0046] Free radical initiators are used to promote cross-linking of the base rubber and the cross-linking agent. Suitable free radical initiators for use in the golf ball core 12 of the present invention include peroxides such as dicumyl peroxide, bis-(t-butyl peroxy) diisopropyl benzene, t-butyl perbenzoate, di-t-butyl peroxide, 2,5-dimethyl-2,5-di-5-butylperoxy-hexane, 1,1-di (t-butylperoxy) 3,3,5-trimethyl cyclohexane, and the like, all of which are readily commercially available.

[0047] Zinc oxide is also preferably included in the core formulation. Zinc oxide may primarily be used as a weight adjusting filler, and is also believed to participate in the cross-linking of the other components of the core (e.g. as a co-agent). Additional processing aids such as dispersants and activators may optionally be included. In particular, zinc stearate may be added as a processing aid (e.g. as an activator). Any of a number of specific gravity adjusting

fillers may be included to obtain a preferred total weight of the core 12. Examples of such fillers include tungsten and barium sulfate. All such processing aids and fillers are readily commercially available. The present inventors have found a particularly useful tungsten filler is WP102 Tungsten (having a 3 micron particle size) available from Atlantic Equipment Engineers (a division of Micron Metals, Inc.), Bergenfield, NJ.

[0048] Table One below provides the ranges of materials included in the preferred core formulations of the present invention.

Table One		
Component	Preferred Range	Most Preferred Range
Polybutadiene	100 parts	100 parts
Zinc diacrylate	20-35 phr	25-30 phr
Zinc oxide	0-50 phr	5-15 phr
Zinc stearate	0-15 phr	1-10 phr
Peroxide	0.2 – 2.5 phr	0.5 – 1.5 phr
Filler (e.g. tungsten)	As desired (e.g. 2-10 phr)	As desired (e.g. 2-10 phr)

[0049] In the present invention, the core components are mixed and compression molded in a conventional manner known to those skilled in the art. In a preferred form, the finished core 12 has a diameter of about 1.35 to about 1.64 inches

for a golf ball 10 having an outer diameter of 1.68 inches. The core weight is preferably maintained in the range of about 32 to about 40 g. The core PGA compression is preferably maintained in the range of about 50 to 90, and most preferably about 55 to 80.

[0050] As used herein, the term "PGA" compression is defined as follows:

[0051]  $\text{PGA compression value} = 180 - \text{Riehle compression value}$

[0052] The Riehle compression value is the amount of deformation of a golf ball in inches under a static load of 200 pounds, multiplied by 1000. Accordingly, for a deformation of 0.095 inches under a load of 200 pounds, the Riehle compression value is 95 and the PGA compression value is 85.

[0053] As is described above, the present invention preferably includes at least one boundary layer 14 that preferably is composed of a thermoplastic (e.g. thermoplastic or thermoplastic elastomer) or a blend of thermoplastics (e.g. metal containing, non-metal containing or both). However, the golf ball 10 may have several boundary layers 14 disposed between the core 12 and the cover 16. Most preferably the boundary layer 14 is composed of at least one thermoplastic that contains organic chain molecules

and metal ions. The metal ion may be, for example, sodium, zinc, magnesium, lithium, potassium, cesium, or any polar metal ion that serves as a reversible cross-linking site and results in high levels of resilience and impact resistance. Suitable commercially available thermoplastics are ionomers based on ethylene copolymers and containing carboxylic acid groups with metal ions such as described above. The acid levels in such suitable ionomers may be neutralized to control resiliency, impact resistance and other like properties. In addition, other fillers with ionomer carriers may be used to modify (e.g. preferably increase) the specific gravity of the thermoplastic blend to control the moment of inertia and other like properties. Exemplary commercially available thermoplastic materials suitable for use in a boundary layer 14 of a golf ball 10 of the present invention include, for example, the following materials and/or blends of the following materials: HYTREL® and/or HYLENE® products from DuPont, Wilmington, Delaware, PEBAX® products from Elf Atochem, Philadelphia, Pennsylvania, SURLYN® products from DuPont, and/or ESCOR® or IOTEK® products from Exxon Chemical, Houston, Texas.

[0054] The Shore D hardness of the boundary layer 14 ranges

from 50 to 75, as measured according to ASTM D-2290. It is preferred that the boundary layer 14 have a hardness of between about 55–70 Shore D. In a preferred embodiment, the boundary layer 14 has a Shore D hardness in the range of 58–65. One reason for preferring a boundary layer 14 with a Shore D hardness of 75 or lower is to improve the feel of the resultant golf ball. It is also preferred that the boundary layer 14 is composed of a blend of SURLYN® ionomer resins.

[0055] SURLYN®8150, 9150, and 6320 are, respectively, an ionomer resin composed of a sodium neutralized ethylene/methacrylic acid, an ionomer resin composed of a zinc neutralized ethylene/methacrylic acid, and an ionomer resin composed of a terpolymer of ethylene, methacrylic acid and n-butyl acrylate partially neutralized with magnesium, all of which are available from DuPont, Polymer Products, Wilmington, DE.

[0056] Exemplary golf balls of the present invention were constructed and compared to the CALLAWAY GOLF RULE 35 FIRMFEEL golf ball. Table Two and Table Three set forth the physical properties of the exemplary group of golf balls #1, #2 and #3. A dozen golf balls were constructed for each group #1, #2 and #3. Each of the boundary layers

14 of the exemplary golf balls #1, #2 and #3 were composed of an ionomer blend of forty-five weight percent SURLYN 8150, forty-five weight percent SURLYN 9150 and ten weight percent SURLYN 6350. The average thickness of each of the boundary layers 14 of the exemplary golf balls #1, #2 and #3 was 0.0525 inch. The Shore D hardness of the boundary layer 14 of the exemplary golf balls #1, #2 and #3 was 62 points. The Shore D hardness provided in Table Three below was determined according to ASTM D2240.

[0057] Each of the covers 16 of the exemplary group of golf balls #1, #2 and #3 were composed of a polytetramethylene ether glycol terminated toluene diisocyanate prepolymer (ADRIPRENE LF930) cured with a blend of seventy weight percent diethyl 2,4-toluenediamine (E100) and thirty weight percent 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline (LONZACURE). The average thickness of each of the covers 16 of the exemplary golf balls #1, #2 and #3 was 0.030 inch. The Shore D hardness of the covers 16 of the exemplary golf balls #1, #2 and #3 was 51 points. The COR at 143 feet per second of each of the exemplary golf balls #1, #2 and #3 was 79.42 points.

Table Two					
Ball	Bound. Layer Shore D (points)	Cover Shore D (points)	Thickness (inch)	Bound. Layer Thickness (inch)	Cover COR (points)
1	62	51	0.0525	0.030	79.42
2	62	51	0.0525	0.030	79.42
3	62	51	0.0525	0.030	79.42

[0058] The average weight of each of the exemplary golf balls #1, #2 and #3 was 45.29 grams. The PGA compression of each of the exemplary golf balls #1, #2 and #3 was 95. The average diameter of each of the exemplary golf balls



#1, #2 and #3 was 1.683 inch. The core diameter of each of the cores 12 of each of the exemplary golf balls #1, #2 and #3 was 1.515 inches. The PGA compression of each of the cores 12 of each of the exemplary golf balls #1, #2 and #3 was 70 points.

Table Three					
Ball	Ball Weight (grams)	Ball Compression (points)	Average Core Diameter (inches)	Core Diameter	Compression
1	45.29	95	1.683	1.515	70
2	45.29	95	1.683	1.515	70
3	45.29	95	1.683	1.515	70

[0059] Tables Four, Five, Six, Seven, Eight and Nine compare the CALLAWAY GOLF RULE 35 FIRMFEEL golf ball to the exemplary golf balls #1, #2 and #3 of the present invention. The golf balls were measured to determine the yellowing

of the thermosetting polyurethane covers after exposure to sunlight. The color of the cover of each of the golf balls is determined using a HUNTER COLORIMETER model ULTRA SCAN XE and measuring the color on a L.a. b. scale. On the "L" scale, a measurement of 100 corresponds to complete white while a measurement of 0 corresponds to complete black. On the "a" scale, a negative number corresponds to a green color while a positive number corresponds to a red color. On the "b" scale, a negative number corresponds to a blue color while a positive number corresponds to a yellow color. Thus, the more positive the b measurement, the more yellow the cover. The golf balls were measured before exposure to sunlight, after four hours of exposure to sunlight and after twenty-four hours of exposure to sunlight/night. The average of the CALLAWAY GOLF RULE 35 FIRMFEEL golf balls after four hours of exposure to sunlight is set forth in Table Five. The average of the exemplary golf balls #1, #2 and #3 of the present invention after four hours of exposure to sunlight is set forth in Table Six. The average of the CALLAWAY GOLF RULE 35 FIRMFEEL golf balls after twenty-four hours of exposure to sunlight/night is set forth in Table Eight. The average of the exemplary golf balls #1, #2 and #3 of

the present invention after twenty-four hours of exposure to sunlight is set forth in Table Nine.

Table Four

Ball	Before Exposure			After 4 Hour Exposure			Difference		
	L	a*	b*	L	A*	b*	L	a*	b*
Rule 35 Firm #1	93.2	-1.26	9.07	75.94	7.91	38.22	-17.26	9.17	29.15
Rule 35 Firm #2	93.15	-1.24	9.18	76.77	7.3	38.42	-16.38	8.54	29.24
Rule 35 Firm #3	93.03	-1.28	8.88	76.65	7.11	37.81	-16.38	8.39	28.93
Ex. 1	95.09	-1.5	2.04	83.09	0.27	21.18	-12	1.77	19.14
Ex. 2	95.12	-1.51	2.19	85.57	-0.47	19.16	-9.55	1.04	16.97
Ex. 3	95.55	-1.52	2.6	89.12	-1.44	15.78	-6.43	0.08	13.18

Table Five

Average for RULE 35 Balls

L	a*	b*	DE
-16.67	8.70	29.11	34.65

Table Six

Average for Exemplary Balls of the Present Invention

L	a*	b*	DE
-9.33	0.96	16.43	18.92

Table Seven

Ball	Before Exposure			After 24 Hour Exposure			Difference		
	L	a*	b*	L	a*	b*	L	a*	b*
Rule 35 Firm #1	93.2	-1.26	9.07	69.42	13.12	40.59	-23.78	14.38	31.52
Rule 35 Firm #2	93.15	-1.24	9.18	69.71	12.85	40.53	-23.44	14.09	31.35
Rule 35 Firm #3	93.03	-1.28	8.88	70.61	12.03	40.34	-22.42	13.31	31.46
Ex. 1	95.09	-1.5	2.04	73.95	3.26	24.36	-21.14	4.76	22.32
Ex. 2	95.12	-1.51	2.19	79.74	1.27	21.72	-15.38	2.78	19.53
Ex.3	95.55	-1.52	2.6	86.03	-0.46	19.67	-9.52	1.06	17.07

Table Eight

Average for RULE 35 Balls

L	a*	b*	DE
-23.21	13.93	31.44	41.49

Table Nine

Average for Exemplary Balls

L	a*	b*	DE
-15.35	2.87	19.64	25.09

[0060] As is shown in Tables Four, Five, Six, Seven, Eight and Nine, the exemplary golf balls #1, #2 and #3 of the present invention have a lower yellow measurement ("b" scale) before exposure, and a lower increase in yellowing

after four hours and twenty four hours as compared to the CALLAWAY GOLF RULE 35 FIRMFEEL golf balls. For example, the #3 golf ball of the present invention had a "b" measurement of 2.6 before exposure, a measurement of 15.78 after four hours of exposure to sunlight, and a measurement of 19.67 after twenty-four hours of exposure. The #3 CALLAWAY GOLF RULE 35 FIRMFEEL golf ball had a "b" measurement of 8.88 before exposure, a measurement of 37.81 after four hours of exposure to sunlight, and a measurement of 40.34 after twenty-four hours of exposure. The golf balls were exposed to sunlight on the rooftop of a building in Carlsbad, California (latitude 32 46 30 north, longitude 117 25 06 west) on a winter day. Thus, not only do the covers 16 of the golf balls of the present invention have less yellowing to begin with, after exposure to sunlight the covers 16 yellow less than other covers composed of thermosetting polyurethane.

[0061] A second exemplary set of golf balls of the present invention were tested for yellowing after exposure to sunlight. These second exemplary set of golf balls were compared to other commercial golf balls with thermosetting polyurethane covers. Each of the boundary layers 14 of

the second exemplary set of golf balls were composed of an ionomer blend of forty-five weight percent SURLYN 8150, forty-five weight percent SURLYN 9150 and ten weight percent SURLYN 6350. The average thickness of each of the boundary layers 14 of the second exemplary set of golf balls 0.0525 inch, and the Shore D hardness of the boundary layer 14 was 62 points. The Shore D hardness was determined according to ASTM D2240.

[0062] Each of the covers 16 of the second exemplary set of golf balls were composed of a polypropylene glycol terminated toluene diisocyanate prepolymer (ADRIPRENE LFG960) cured with a blend of seventy weight percent diethyl 2,4-toluenediamine (E100) and thirty weight percent 4,4'-methylenebis-(3-chloro,2,6-diethyl)-aniline (LONZACURE). The average thickness of each of the covers 16 of the second exemplary set of golf balls was 0.030 inch and the Shore D hardness of the covers 16 was 51 points. The COR at 143 feet per second of each of the second exemplary set of golf balls was 79.42 points.

[0063] As shown in FIG. 3, the second exemplary set of golf balls were compared to the CALLAWAY GOLF RULE 35 FIRMFEEL golf ball, the MAXFLI REVOLUTION golf ball (wound) and the TITLEIST PROFESSIONAL golf ball (wound). The paint

was removed from a portion of the commercial golf balls to expose the cover material. The group A golf balls of the second exemplary set of golf balls were post cured in a natural convection type oven and the group B golf balls of the second exemplary set of golf balls were post cured in a Lanley type oven. The golf balls were exposed for forty-eight hours and the color difference over time was measured for each of the golf balls. The second exemplary set of golf balls had a lower color difference over time than all of the other golf balls.

[0064] From the foregoing it is believed that those skilled in the pertinent art will recognize the meritorious advancement of this invention and will readily understand that while the present invention has been described in association with a preferred embodiment thereof, and other embodiments illustrated in the accompanying drawings, numerous changes, modifications and substitutions of equivalents may be made therein without departing from the spirit and scope of this invention which is intended to be unlimited by the foregoing except as may appear in the following appended claims. Therefore, the embodiments of the invention in which an exclusive property or privilege is claimed are defined in the following appended claims.